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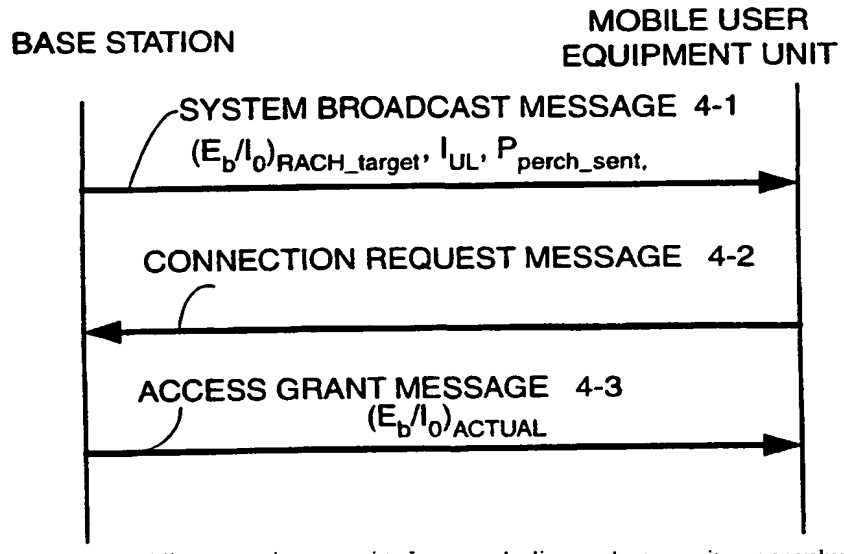

(57) Abstract: A transmit power value (P_{RACH}) for a connection request message (RACH) from a mobile user equipment unit (20) to a telecommunications network (18) is determined using a target ratio of received energy to interference value $[(E_b/I_O)_{RACH_target}]$ and a modification factor $[(E_b/I_O)_{MEAN_DELTA}]$. The modification factor is a sliding mean differential between the target ratio and an actual ratio $[(E_b/I_O)_{ACTUAL}]$ of received energy to interference as determined by the telecommunications network. The modification factor allows for the calculation of the transmit power for the connection request message to be adaptive with respect to a changing characteristic of the mobile user equipment unit (e.g., aging of the mobile user equipment unit). In one embodiment, the transmit power value determination is made at the mobile user equipment unit.

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ADAPTIVE RACH POWER DETERMINATION FOR MOBILE TELECOMMUNICATIONS USER EQUIPMENT UNIT

BACKGROUND

1. FIELD OF THE INVENTION

The present invention pertains to cellular telecommunications, and particularly to determining broadcast power to be used by a mobile user equipment unit when requesting access to a cellular telecommunications network.

2. RELATED ART AND OTHER CONSIDERATIONS

Cellular telecommunications systems employ a wireless link (e.g., air interface) between the (mobile) user equipment and a base station (BS). The base station has transmitters and receivers for radio connections with numerous user equipment units. One or more base stations are connected (e.g., by landlines or microwave) and managed by a radio network controller (also known in some networks as a base station controller [BSC]). The radio network controller is, in turn, connected through control nodes to a core communications network. Control nodes can take various forms, depending on the types of services or networks to which the control nodes are connected. For connection to connection-oriented, switched circuit networks such as PSTN and/or ISDN, the control node can be a mobile switching center (MSC). For connecting to packet switching data services such as the Internet (for example), the control node can be a gateway data support node through which connection is made to the wired data networks, and perhaps one or more serving nodes.

When a mobile user equipment unit desires to initiate a connection with a base station, the user equipment unit typically sends a connection request message to the base station on a Random Access Channel (RACH). The RACH is a common channel that is

available for all user equipment units within a geographical area or cell covered by the base station. The connection request message carried on the RACH generally includes various types of other information, such as (for example) signal strength of the received broadcast channel (so that the base station can calculate the transmission power to use) and some random number for (with probability) making the connection unique in the cll during the initial communication on the common channels (RACH and FACH). It is anticipated that the RACH may also be used for packet data in new telecommunications systems, such as wideband CDMA (WCDMA).

When a mobile user equipment unit sends its connection request message on the RACH, the user equipment unit must first calculate the transmit power that its transmitter will use for sending the connection request message. Preferably, in calculating the transmit power, the user equipment unit will use a transmission power which (hopefully) will be the lowest possible transmission power possible, thereby reducing interference for other users. But if the base station fails to receive the connection request message, the user equipment unit must repeat the transmission of its connection request until the base station successfully receives the connection request message, else the attempt to send the connection request is terminated as being unsuccessful.

According to a current technique, if the user equipment unit calculates too low a transmission power (thereby making it impossible for the base station to receive the connection request message), the user equipment unit increases its transmit output power for a successive connection requests (e.g., for each new connection request attempt). However, this current technique presents numerous problems.

A first set of problems can occur when the initially calculated transmit power for the connection request is too low. In such case, the power calculation for transmission of the next connection request, although increased, will probably also be too low. Moreover, the first connection request, sent at a transmit power too low to be received by the base station, can exacerbate the situation by increasing the interference for other user equipment units (perhaps causing them to increase their respective transmit powers) and consuming battery power in the requesting user equipment unit. Further, the delay in sending the next connection request message will likely be increased.

A second set of problems can occur when the initially calculated RACH transmit power is higher than necessary. In such case, the connection request message, sent at a greater-than-necessary power, increases interference for other users. In addition, the transmission of the connection request message consumes more power than necessary in the requesting user equipment unit.

A third set of problems involves aging of the user equipment unit. As a user equipment unit ages, under otherwise identical conditions the user equipment unit can require a different transmit power than when it was new due, e.g., to changing characteristics of the transmitter and/or receiver components. As a result, the user equipment unit will likely use too high or too low a transmit power for its first connection request.

Prior art RACH power determination techniques are discussed in the patent literature. See, for example, US Patent 5,806,003 to Jolma et al.; US Patent 5,487,180 to Ohtake; and US Patent 5,333,175 to Ariyavisitakul et al.

What is needed, therefore, and an object of the present invention, is a technique which is adaptive for changing characteristics of the mobile user equipment unit for determining transmit power when making a connection request.

BRIEF SUMMARY OF THE INVENTION

A transmit power value (P_{RACH}) for a connection request message (RACH) from a mobile user equipment unit (20) to a telecommunications network (18) is determined using a target ratio of received energy to interference value $[(E_b/I_0)_{RACH_target}]$ and a modification factor $[(E_b/I_0)_{MEAN_DELTA}]$. The modification factor is a sliding mean differential between the target ratio and an actual ratio $[(E_b/I_0)_{ACTUAL}]$ of received energy to interference as determined by the telecommunications network. The modification factor allows for the calculation of the transmit power for the connection request message to be adaptive with respect to a changing characteristic of the mobile user equipment unit (e.g., aging of the mobile user equipment unit).

The modification factor is obtained by taking a mean of a set of differentials $[(E_b/I_0)_{DELTA}]$. Each differential of the set is a difference between the target ratio and

the actual ratio. Plural differentials of the set are compiled with respect to a corresponding plural number of previous connection request messages. Preferably the set of differentials are stored in a FIFO, so that a sliding mean of the plural (n) differential values maintained in the FIFO can be determined and used as the modification factor $[(E_b/I_0)_{MEAN_DELTA}]$.

Determining the transmit power value for the connection request message comprises evaluating the expression $P_{RACH} = C_{RACH} + (E_b/I_0)_{ADAPTED\ TARGET} + I_{UL} + P_{perch_sent} - P_{perch_meas}$ wherein P_{RACH} is transmit power for the connection request message calculated by the on-board unit; C_{RACH} is a constant depending on rate, channel coding, and carrier bandwidth; I_{UL} is uplink interference determined at the telecommunications network; P_{perch_sent} is downlink output power used for a broadcast channel; P_{perch_meas} is received broadcast channel power measured at the user equipment unit; $(E_b/I_0)_{ADAPTED\ TARGET}$ is an adaptive target E_b/I_0 for the connection request message.

The value $(E_b/I_0)_{ADAPTED\ TARGET}$ is determined using the target energy to power ratio $(E_b/I_0)_{RACH_target}$ as specified by the telecommunications network and the modification factor. The uplink interference (I_{UL}), downlink output power for the broadcast channel (P_{perch_sent}), and target energy to power ratio $[(E_b/I_0)_{RACH_target}]$ are transmitted to the mobile user equipment unit in a broadcast channel message. After the mobile user equipment unit successfully completes the connection request message, the telecommunications network sends a access grant message which includes an actual ratio of received energy to interference $[(E_b/I_0)_{ACTUAL}]$ determined by the network for use as a latest differential affecting the modification factor for the next connection request message from the mobile user equipment unit.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features, and advantages of the invention will be apparent from the following more particular description of preferred embodiments as illustrated in the accompanying drawings in which reference characters refer to the same parts throughout the various views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention.

Fig. 1 is a schematic view of an embodiment of a telecommunications system which utilizes the present invention.

Fig. 2 is a diagrammatic view of a mobile user equipment unit which participates in the telecommunications system of Fig. 1.

Fig. 3 is a schematic view of an example base station node according to an embodiment of the invention.

Fig. 4 is a diagrammatic view showing a sequence of messages transmitted between a telecommunications network and a user equipment unit germane to a RACH transmit power calculation process of the present invention.

Fig. 5 is a flowchart showing basic steps involved in a RACH transmit power calculation process of the present invention.

Fig. 6 is a diagrammatic view of a RACH transmit power historical information FIFO.

DETAILED DESCRIPTION OF THE DRAWINGS

In the following description, for purposes of explanation and not limitation, specific details are set forth such as particular architectures, interfaces, techniques, etc. in order to provide a thorough understanding of the present invention. However, it will be apparent to those skilled in the art that the present invention may be practiced in other embodiments that depart from these specific details. In other instances, detailed descriptions of well known devices, circuits, and methods are omitted so as not to obscure the description of the present invention with unnecessary detail.

Fig. 1 shows a telecommunications network 18 in which a user equipment unit 20 communicates with one or more base stations 22 over air interface (e.g., radio interface) 23. Base stations 22 are connected by terrestrial lines (or microwave) to radio network controller (RNC) 24 [also known as a base station controller (BSC) in some networks]. The radio network controller (RNC) 24 is, in turn, connected through a control node known as the mobile switching center 26 to circuit-switched telephone

networks (PSTN/ISDN) represented by cloud 28. In addition, radio network controller (RNC) 24 is connected to Serving GPRS Support Node (SGSN) 25 and through backbone network 27 to a Gateway GRPS support node (GGSN) 30, through which connection is made with packet-switched networks (e.g., the Internet, X.25 external networks) represented by cloud 32.

As understood by those skilled in the art, when user equipment unit 20 participates in a mobile telephonic connection, signaling information and user information from user equipment unit 20 are transmitted over air interface 23 on designated radio channels to one or more of the base stations 22. The base stations have radio transceivers which transmit and receive radio signals involved in the connection or session. For information on the uplink from the user equipment unit 20 toward the other party involved in the connection, the base stations convert the radio-acquired information to digital signals which are forwarded to radio network controller (RNC) 24. The radio network controller (RNC) 24 orchestrates participation of the plural base stations 22 which may be involved in the connection or session, since user equipment unit 20 may be geographically moving and handover may be occurring relative to the base stations 22. On the uplink, radio network controller (RNC) 24 picks frames of user information from one or more base stations 22 to yield a connection between user equipment unit 20 and the other party, whether that party be in PSTN/IDSN 28 or on the packet-switched networks (e.g., the Internet) 32.

An illustrative embodiment of a suitable user equipment unit 20 for the present invention is provided in Fig. 2. As shown in Fig. 2, user equipment unit 20 has the mobile termination entity (MT) 40; terminal adapter (TA) 42; and terminal equipment (TE) 44, each of which is discussed briefly hereafter.

Mobile termination entity (MT) 40, which is sometimes called the Mobile Equipment (ME), contains the radio transmitter/receiver (with antenna 61) and communications control toward the network, e.g., the setup and release of radio connections, handover, etc. Mobile termination entity (MT) 40 can be a standard mobile pocket telephone (e.g., a GSM phone) or a phone card within user equipment unit 20.

Terminal adapter (TA) 42 acts as an adaptation between mobile termination entity (MT) 40 and a set of applications executed by the terminal equipment. The terminal adapter (TA) 42 is typically realized as a Modem implemented on a PCMCIA (Personal Computer Memory Card International Association) card, which is inserted in a slot of terminal equipment 44.

Terminal equipment 44 is normally a small computer (or computer platform), and as such includes both hardware and software. Terminal equipment 44 thus has typical aspects of a computer platform, e.g., a processor with operating system and middleware (Internet protocol suits, for example). In addition, terminal equipment 44 has control logic 72 (executed by the processor) for controlling terminal adapter (TA) 42. Control logic 72 performs set-up and release of calls to and from the network 18. In essence, Fig. 2 shows terminal equipment 44 wherein mobile termination entity (MT) 40 and terminal adapter (TA) 42 are cards situated in card slots. Terminal adapter (TA) 42 is connected to central processing unit (CPU) 100 by bus 102. Mobile termination entity (MT) is connected to MT interface 65 of terminal adapter (TA) 42 by a cable. Memories of terminal equipment 44, particularly read only memory (ROM) 104 and random access memory (RAM) 106 are also connected to central processing unit (CPU) 100 by bus 102. Terminal equipment 44 interfaces with a user through input device(s) 110 and output device(s) 112, each connected through respective appropriate interfaces 120 and 122 to bus 102. Input device(s) 110 can be a keyboard and/or mouse, for example, while output device(s) 112 can take the form of a display device, such as a LCD display panel, for example.

It should be understood that the invention is not confined to user equipment units having the same physical separation between functional entities as shown in Fig. 2, and that the present invention can be implemented in other than the described functional/structural configuration.

An example base station (BS) 22 is shown in Fig. 3 as comprising a switch 260. Switch 260, which is controlled by base station control unit 262, has a plurality of ports. At least one, and typically several, of the ports of switch 260 are connected to respective transceiver (Tx/Rx) boards 264. Transceiver (Tx/Rx) boards 264 are connected to antennae which are located in the cell served by the base station (BS) 22. Control unit 262 is also connected to ports of switch 260, as are a terminal board 266 and a power

control unit 268. It is through terminal board 266 that base station (BS) 22 communications with its radio network controller (RNC) 24, with link 225 being connected between an appropriate base station interface unit 248 of the radio network controller (RNC) 24 (see Fig. 1 and Fig. 3) and terminal board 266. Power control unit 268 performs numerous functions, including determining a signal-to-noise ratio (SNR) and quality of connection (QOC) parameter for a received signal from each user equipment unit 20 with which base station 22 is in communication and sending a power change command when necessary to the user equipment units 20 for which it is responsible. These and other functions performed by power control unit 268 concerning established connections are understood with reference, e.g., to U.S. Patent Application SN 08/916,440, entitled "Signaling Method for CDMA Quality Based Power Control", which is incorporated herein by reference. In addition, power control unit 268 sets the downlink power level at which base station 22 is to transmit its broadcast channel message, e.g., P_{perch_sent}. If desired, the functions of power control unit 268 can be consolidated in a single unit with BS control unit 262.

In accordance with the present invention, the user equipment unit 20 has an on-board unit which makes a calculation of a transmit power to be used for a connection request message to telecommunications network 18. Advantageously, the calculation of the transmit power is adaptive with respect to a changing characteristic of the user equipment unit 20, i.e., age of the user equipment unit 20.

In the above regard, the CPU 100 of user equipment unit 20 executes a RACH transmit power calculation process 200 (see Fig. 2). The RACH transmit power calculation process 200 is a set of coded instructions which can be stored in a memory (e.g., ROM 104) and loaded into CPU 100 for execution. In execution RACH transmit power calculation process 200, the CPU 100 utilizes transmit power historical information stored in a portion of RAM 106 depicted as RACH transmit power historical information FIFO 202 (see Fig. 2). RAM 106 must be of a non-volatile type which maintains the data stored therein even when the user equipment unit 20 is turned off.

The RACH transmit power calculation process 200 of the present assumes that various parameters are made available from telecommunications network 18. In this regard, it is required that RACH transmit power calculation process 200 be advised by

telecommunications network 18 of (1) the uplink interference I_{UL} experienced by the telecommunications network 18; and (2) the downlink output power P_{perch_sent} which is used for a broadcast channel. In addition, RACH transmit power calculation process 200 assumes the user equipment unit 20 can measure the broadcast channel power P_{perch_meas} which user equipment unit 20 receives. Each of these three values -- I_{UL}, P_{perch_sent}, and P_{perch_meas} are stored in an appropriate memory for use by RACH transmit power calculation process 200, e.g., stored in RAM 106.

Fig. 4 shows a selected sequence of messages, germane to RACH transmit power calculation process 200, which occurs in telecommunications network 18. Fig. 4 shows as message 4-1 a broadcast channel message which is transmitted, preferably over a common channel such as BCCH, to user equipment unit 20. Although Fig. 4 shows only one such broadcast channel message 4-1, it should be understood that such messages are typically periodically transmitted, such that an entire series of broadcast channel messages 4-1 could, in fact, be illustrated. The broadcast channel message 4-1 can include numerous fields of information, in a manner known in the prior art, but for the purpose of the present invention includes, e.g., fields for the uplink interference I_{UL} experienced by the telecommunications network 18, the downlink output power P_{perch_sent} which is used for the broadcast channel message 4-1, and the target RACH transmit power $(E_b/I_0)_{RACH_target}$ that telecommunications network 18 prefers for mobile user equipment unit 20 to utilize when sending a connection request message.

The broadcast channel message 4-1 shown in Fig. 4 emanates from base station 22 of telecommunications network 18, and in particular is prepared and formatted by BS control unit 262. However, base station 22 obtains values for the parameters uplink interference I_{UL} experienced by the telecommunications network 18 and the downlink output power P_{perch_sent} from power control unit 268. The base station 22 knows at what values it sets its downlink output power P_{perch_sent} for the broadcast channel message 4-1, and determines the value for the uplink interference I_{UL} as the sum of all interference measured on one frequency in one cell (which includes all uplink radio beams and additional noise).

Fig. 5 shows basic steps involved in the RACH transmit power calculation process 200 of the present invention. The RACH transmit power calculation process 200 is performed in order to determine a transmit power P_{RACH} to be used for

transmitting the connection request message to be sent by mobile user equipment unit 20. The connection request message is illustrated as message 4-2 in Fig. 4.

Step 5-1 shows RACH transmit power calculation process 200 checking whether the user of mobile user equipment unit 20 has indicated a desire to initiate a call. If it is determined at step 5-1 that a call is to be placed from mobile user equipment unit 20, at step 5-2 the RACH transmit power calculation process 200 fetches from memory the values stored for the parameters P_{perch_sent} (downlink output power of the broadcast channel message 4-1 as ascertained from the broadcast channel message 4-1); I_{UL} (uplink interference at the base station 22 as specified in the broadcast channel message 4-1); and target RACH transmit power $(E_b/I_0)_{RACH_target}$.

At step 5-3 RACH transmit power calculation process 200 measures the received power of the broadcast channel message 4-1 to obtain a value for P_{perch_meas}. Thus, P_{perch_meas} is received broadcast channel power measured at the user equipment unit 20.

At step 5-4 the RACH transmit power calculation process 200 fetches a constant value C_{RACH} from memory. The parameter C_{RACH} is a constant depending on rate, channel coding, and carrier bandwidth. In general, the parameter C_{RACH} is a relation between signal interference level and E_b/I_0. In particular, in one illustrative embodiment of the invention, the parameter C_{RACH} is determined by the following expression:

$$C_{RACH} = 2dB + CR\ dB - CB\ dB + SR\ dB$$

wherein CR is coding rate; CB is carrier bandwidth; SR is symbol rate. In one example, CR = ½ (= -3.01dB); SR is 16 ksps (= 42.04dB); BW is 4.096 Mcps (= 66.12dB); which gives C_{RACH} = -25.1 dB.

At step 5-5 the RACH transmit power calculation process 200 determines a modification factor. The modification factor is a mean value of RACH power differentials historically compiled in FIFO 202 (see Fig. 2). In this regard, and as illustrated in Fig. 6, RACH transmit power historical information FIFO 202 includes a first-in, first-out set of n memory locations for storing historically gathered values of a parameter $(E_b/I_0)_{DELTA}$. As explained below, the n samples of the parameter (E_b/I_0)

$_{DELTA}$ were obtained upon occasion of the n number of previous successful RACH messages sent from mobile user equipment unit 20. Those skilled in the art will recognize the ratio (E_b/I_0) as being the ratio of energy to interference as determined by the telecommunications network.

As illustrated in Fig. 6, the first value in RACH transmit power historical information FIFO 202, i.e., $(E_b/I_0)_{DELTA}(last)$, was stored upon the immediately previous successful transmission of a connection request (RACH) message. The second value $[(E_b/I_0)_{DELTA}(last-1)]$ was stored upon the next older (i.e., penultimate) successful transmission of a connection request (RACH) message; and so forth to the last value $[(E_b/I_0)_{DELTA}(last-n+1)]$. Each of the values in RACH transmit power historical information FIFO 202, generically referred to as $(E_b/I_0)_{DELTA}$, is computed to be a difference between the value $(E_b/I_0)_{RACH_target}$ (obtained from broadcast channel message 4-1 as depicted at step 5-1) and a value $(E_b/I_0)_{ACTUAL}$. As explained below, after a successful connection request message 4-2 is sent, an access grant message is received. An example access grant message is illustrated as message 4-3 in Fig. 4. The access grant message 4-3 includes a value for $(E_b/I_0)_{ACTUAL}$ with respect to the RACH message which prompted the access grant message 4-3. The value for $(E_b/I_0)_{ACTUAL}$ is the actual ratio of received energy to interference as determined by the telecommunications network, and particularly as determined by power control unit 268 of base station 22. Then, after a successful connection request message 4-2, a new $(E_b/I_0)_{DELTA}(last)$ is calculated as the difference between the value $(E_b/I_0)_{RACH_target}$ and the value $(E_b/I_0)_{ACTUAL}$ received in the corresponding access grant message 4-3 (see step 5-12).

Thus, at step 5-5 a mean of the values $(E_b/I_0)_{DELTA}(last)$ through $(E_b/I_0)_{DELTA}(last-n+1)$ is computed. In particular, at step 5-5 the RACH transmit power calculation process 200 determines $(E_b/I_0)_{MEAN_DELTA}$ as the mean of all values stored in RACH transmit power historical information FIFO 202. It is this $(E_b/I_0)_{MEAN_DELTA}$ which is herein referred to as a modification factor, or historical-based modification factor.

Step 5-6 involves RACH transmit power calculation process 200 determining a value for a parameter $(E_b/I_0)_{ADAPTED\ TARGET}$. The parameter $(E_b/I_0)_{ADAPTED\ TARGET}$ is the sum of the value $(E_b/I_0)_{RACH_target}$ (obtained from the broadcast channel message 4-1 and fetched at step 5-1) and the modification factor, i.e., the value $(E_b/I_0)_{MEAN_DELTA}$ (as determined at step 5-5). Then, at step 5-7 the RACH transmit power calculation process

200 uses the calculated value for the parameter $(E_b/I_0)_{ADAPTED\ TARGET}$ to evaluate the following expression for P_{RACH}:

$$P_{RACH} = C_{RACH} + (E_b/I_0)_{ADAPTED\ TARGET} + I_{UL} + P_{perch_sent} - P_{perch_meas}$$

As explained above, C_{RACH} is a constant depending on rate, channel coding, and carrier bandwidth (see step 5-4); I_{UL} is uplink interference determined at the telecommunications network (see step 5-2); P_{perch_sent} is downlink output power used for a broadcast channel (see step 5-2); and, $(E_b/I_0)_{ADAPTED\ TARGET}$ is the adaptive target E_b/I_0 for the connection request message (see step 5-6).

At step 5-8 the RACH transmit power calculation process 200 uses the value of P_{RACH} as calculated at step 5-8 as the transmit power for transmitting the connection request message 4-2 (see Fig. 4). If the amount of power computed at step 5-7 and utilized at step 5-8 proves adequate, an access granted message 4-3 is received by mobile user equipment unit 20. Therefore, after an appropriate time window has elapsed subsequent to the attempted transmission of a connection request message 4-2 at step 5-8, at step 5-9 a check is made by mobile user equipment unit 20 to determine if it has received an access grant message 4-3. If it is determined at step 5-9 that a access grant message 4-3 has not been timely received, at step 5-10 the RACH transmit power calculation process 200 enters a repeat connection request procedure. The details of the repeat connection request procedure of step 5-10 are not pertinent to the present invention, and can involve any appropriate repeat technique including increasing the power amount by a predetermined factor.

Assuming that a access grant message 4-3 is received and so determined at step 5-9, at step 5-11 the RACH transmit power calculation process 200 obtains the value $(E_b/I_0)_{ACTUAL}$ from the access grant message 4-3. The value $(E_b/I_0)_{ACTUAL}$ included in the access grant message 4-3 received at step 5-9 reflects the actual (E_b/I_0) as measured by base station 22 at the time the base station 22 receives the connection request message 4-2 of step 5-8. Then, having obtained the $(E_b/I_0)_{ACTUAL}$, at step 5-11 the RACH transmit power calculation process 200 determines a new $(E_b/I_0)_{DELTA}$ with respect to the connection request message 4-2 of step 5-8 by finding the difference between the $(E_b/I_0)_{ACTUAL}$ obtained at step 5-11 and the value $(E_b/I_0)_{RACH_target}$, and uses the new $(E_b/I_0)_{DELTA}$ as the $(E_b/I_0)_{DELTA}(last)$ in RACH transmit power historical

information FIFO 202. The former value $(E_b/I_0)_{DELTA}(last)$ then becomes $(E_b/I_0)_{DELTA}(last-1)$, and so forth, with the oldest value of $(E_b/I_0)_{DELTA}$ in RACH transmit power historical information FIFO 202 rolling out of the window maintained by RACH transmit power historical information FIFO 202. Such FIFO storing techniques, including the user of a pointer to point to the memory location to be occupied by the next entry (e.g., the "$(E_b/I_0)_{DELTA}(last)$"), are well understood by those skilled in the art.

Thus, upon successful completion of a connection request message 4-2 and storing in RACH transmit power historical information FIFO 202 of a new $(E_b/I_0)_{DELTA}(last)$ with respect thereto, the RACH transmit power calculation process 200 is concluded as indicated by step 5-12.

The equation of step 5-7 is thus adaptive and compensates for poorly tuned equipment in mobile user equipment unit 20. Advantageously, when the RACH transmit power calculation process 200 of the present invention increases transmit power for a connection request message 4-2 upon failure of a base station 22 to receive the same, the power increase is performed in more gradual fashion than in currently prevailing techniques. This is due, at least in part, to the ability of the mobile user equipment unit 20 to take into account that the first calculated transmit power is better, closer to the correct value, with the adaptive tuning of the invention than without. Therefore, the power ramping is less aggressive . Without the present invention, the power ramping must be aggressive for guaranteeing that a RACH is sent with sufficient transmit power which is higher, or equal to, the correct value without too many retransmissions.

In view of the present invention, e.g., the use of the equation of step 5-7, the RACH power calculation of mobile user equipment unit 20 is adaptively changed over the life of mobile user equipment unit 20. In view of the adaptive change, the RACH power level as initially calculated at step 5-7 and utilized at step 5-8 is probably correct. In view of such initial accuracy, there is generally no need to have as aggressive power ramping than otherwise, and therefore less risk of increasing the RACH transmit power to a higher than necessary amount. Moreover, the delay for sending connection request messages 4-2 is decreased in view of the initial accuracy, particularly by comparison to a badly tuned mobile user equipment unit 20 that does not employ the advantageous adaptive calculation features of the present invention.

Thus, the foregoing example has illustrated a sliding mean value technique for achieving adaptability of RACH transmit power. The sliding aspect of the technique is attributed, e.g., to the first-in, first-out aspects of RACH transmit power historical information FIFO 202. Utilization of the mean value serves as a time averaging of most recently acquired $(E_b/I_0)_{DELTA}$ values. It should be understood that other techniques for achieving historical adaptivity of RACH transmit power for mobile user equipment unit 20 can be utilized, such as taking a type of average other than a mean average.

While in the foregoing example various stored parameters have been accorded to certain memories, e.g., RAM 106, it should be understood other choices of storage locations can be utilized.

While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

WHAT IS CLAIMED IS:

1. A mobile user equipment unit (20) which is characterized by having an on-board unit (200) which makes a calculation of a transmit power for a connection request message to a telecommunications network, the calculation of the transmit power being adaptive with respect to a changing characteristic of the mobile user equipment unit.

2. The apparatus of claim 1, wherein the calculation of transmit power reflects aging of the user equipment unit.

3. The apparatus of claim 1, wherein the on-board unit is a processor (100) which executes a set of coded instructions stored in a memory, and wherein execution of the set of coded instructions includes an evaluation of the expression:

$$P_{RACH} = C_{RACH} + (E_b/I_0)_{ADAPTED\ TARGET} + I_{UL} + P_{perch_sent} - P_{perch_meas}$$

wherein

P_{RACH}	is transmit power for the connection request message calculated by the on-board unit;
C_{RACH}	is a constant depending on rate, channel coding, and carrier bandwidth;
I_{UL}	is uplink interference determined at the telecommunications network;
P_{perch_sent}	is downlink output power used for a broadcast channel;
P_{perch_meas}	is received broadcast channel power measured at the user equipment unit;
$(E_b/I_0)_{ADAPTED\ TARGET}$	is an adaptive target E_b/I_0 for the connection request message.

4. The apparatus of claim 3, wherein $(E_b/I_0)_{ADAPTED\ TARGET}$ is computed using a target transmit power specified by the telecommunications network and an historically-based modification factor.

5. The apparatus of claim 4, wherein the historically-based modification factor is maintained by the mobile user equipment unit.

6. The apparatus of claim 5, wherein the historically-based modification factor is a mean of a set of differentials, each differential of the set being a difference between a target ratio of received energy to interference and an actual ratio of received energy to interference as determined by the telecommunications network.

7. The apparatus of claim 6, wherein the set of differentials are compiled with respect to a plural number of previous connection request messages.

8. The apparatus of claim 1, wherein the user equipment unit includes a memory (202) which stores transmit power historical information, and wherein the on-board unit (200) uses the transmit power historical information in making the calculation of the transmit power to be used in making a connection request message to a telecommunications network.

9. The apparatus of claim 8, wherein the memory stores a set of historically compiled differentials, each of the differentials being a difference between a target ratio of received energy to interference and an actual ratio of received energy to interference as determined by the telecommunications network.

10. The apparatus of claim 9, wherein the memory is a FIFO register, and wherein the on-board unit uses a mean value of the historically compiled differentials stored in the FIFO register in making the calculation of the transmit power to be used in making the connection request message to a telecommunications network.

11. The apparatus of claim 10, wherein at least one of the target ratio of received energy to interference and the actual ratio of received energy to interference as determined by the telecommunications network is transmitted from the telecommunications network to the user equipment unit.

12. The apparatus of claim 10, wherein both the target ratio of received energy to interference and the actual ratio of received energy to interference as determined by

the telecommunications network is transmitted from the telecommunications network to the user equipment unit.

13. The apparatus of claim 11, wherein the actual ratio of received energy to interference as determined by the telecommunications network is transmitted from the telecommunications network to the user equipment unit in an access grant message.

14. The apparatus of claim 11, wherein the target ratio of received energy to interference as determined by the telecommunications network is transmitted from the telecommunications network to the user equipment unit in broadcast channel message.

15. A method of operating a mobile user equipment unit (20) which transmits a connection request message to a telecommunications network, the method characterized by:

obtaining a target ratio of received energy to interference value;

determining a transmit power value for the connection request message using the target ratio of received energy to interference value and a modification factor, the modification factor being a differential between the target ratio of received energy to interference and an actual ratio of received energy to interference as determined by the telecommunications network.

16. The method of claim 15, further comprising determining the modification factor at the mobile user equipment unit.

17. The method of claim 15, further comprising determining the modification factor by taking a mean of a set of differentials, each differential of the set being a difference between a target ratio of received energy to interference and an actual ratio of received energy to interference as determined by the telecommunications network.

18. The method of claim 17, further comprising compiling plural differentials of the set with respect to a corresponding plural number of previous connection request messages.

19. The method of claim 15, wherein the step of determining a transmit power value for the connection request message comprises evaluating the expression:

$$P_{RACH} = C_{RACH} + (E_b/I_0)_{ADAPTED\ TARGET} + I_{UL} + P_{perch_sent} - P_{perch_meas}$$

wherein

P_{RACH} is transmit power for the connection request message calculated by the on-board unit;

C_{RACH} is a constant depending on rate, channel coding, and carrier bandwidth;

I_{UL} is uplink interference determined at the telecommunications network;

P_{perch_sent} is downlink output power used for a broadcast channel;

P_{perch_meas} is received broadcast channel power measured at the user equipment unit;

$(E_b/I_0)_{ADAPTED\ TARGET}$ is an adaptive target E_b/I_0 for the connection request message.

20. The method of claim 19, further comprising determining $(E_b/I_0)_{ADAPTED\ TARGET}$ using a target energy to power ratio $(E_b/I_0)_{RACH_target}$ as specified by the telecommunications network and the modification factor.

21. The method of claim 20, further comprising determining the modification factor at the mobile user equipment unit.

22. The method of claim 21, further comprising deriving the modification factor as a mean of a set of differentials, each differential of the set being a difference between a target ratio of received energy to interference and an actual ratio of received energy to interference as determined by the telecommunications network.

23. The method of claim 22, further comprising compiling plural differentials of the set with respect to a corresponding plural number of previous connection request messages.

24. The method of claim 15, further comprising determining a transmit power value for the connection request message at the mobile user equipment unit.

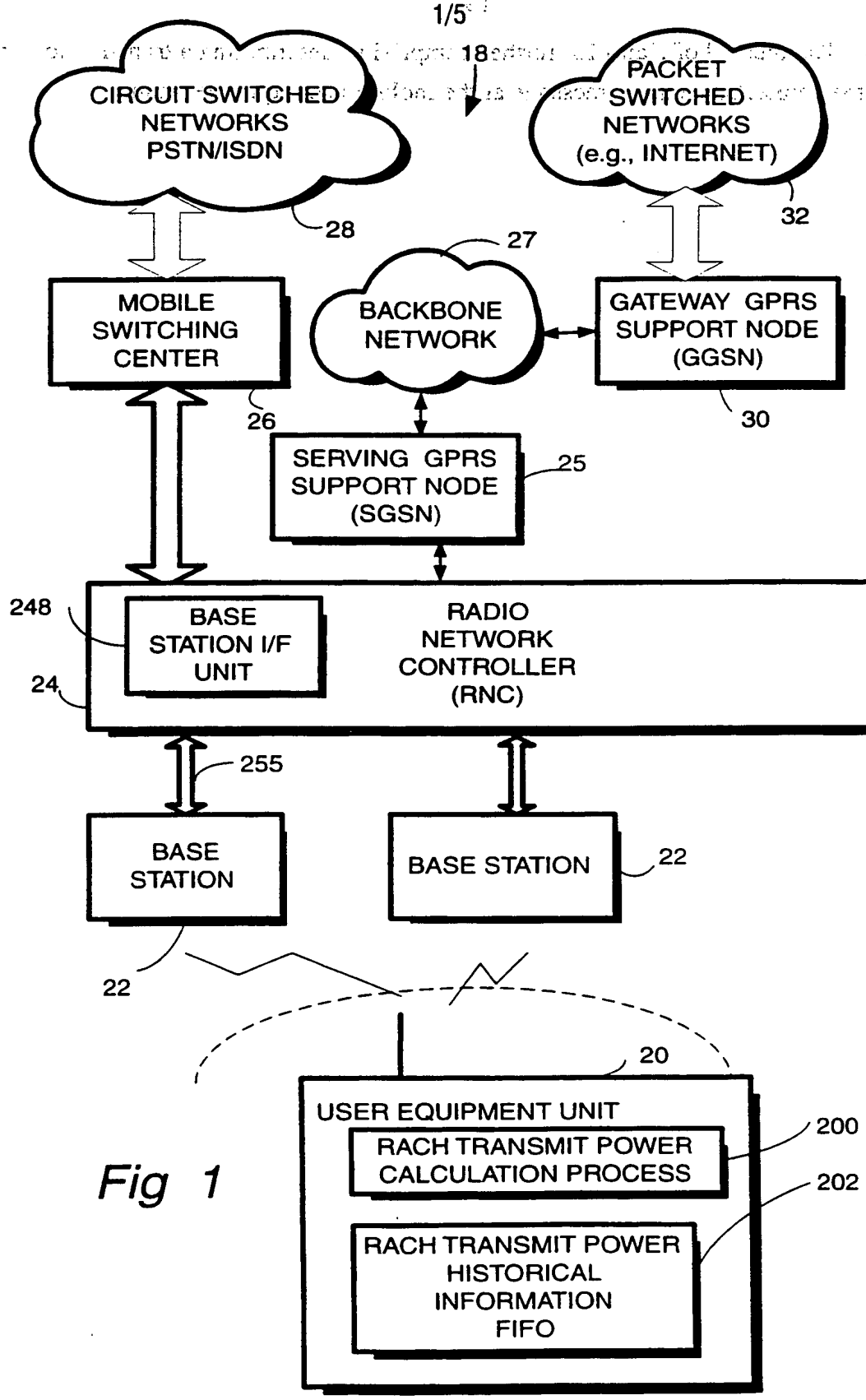

18
CIRCUIT-SWITCHED NETWORKS PSTN/ISDN
28
PACKET SWITCHED NETWORKS (e.g., INTERNET)
32
27
MOBILE SWITCHING CENTER
26
BACKBONE NETWORK
GATEWAY GPRS SUPPORT NODE (GGSN)
30
SERVING GPRS SUPPORT NODE (SGSN)
25
248
BASE STATION I/F UNIT
24
RADIO NETWORK CONTROLLER (RNC)
255
BASE STATION
BASE STATION
22
22
20
USER EQUIPMENT UNIT
RACH TRANSMIT POWER CALCULATION PROCESS
200
202
RACH TRANSMIT POWER HISTORICAL INFORMATION FIFO

Fig 1

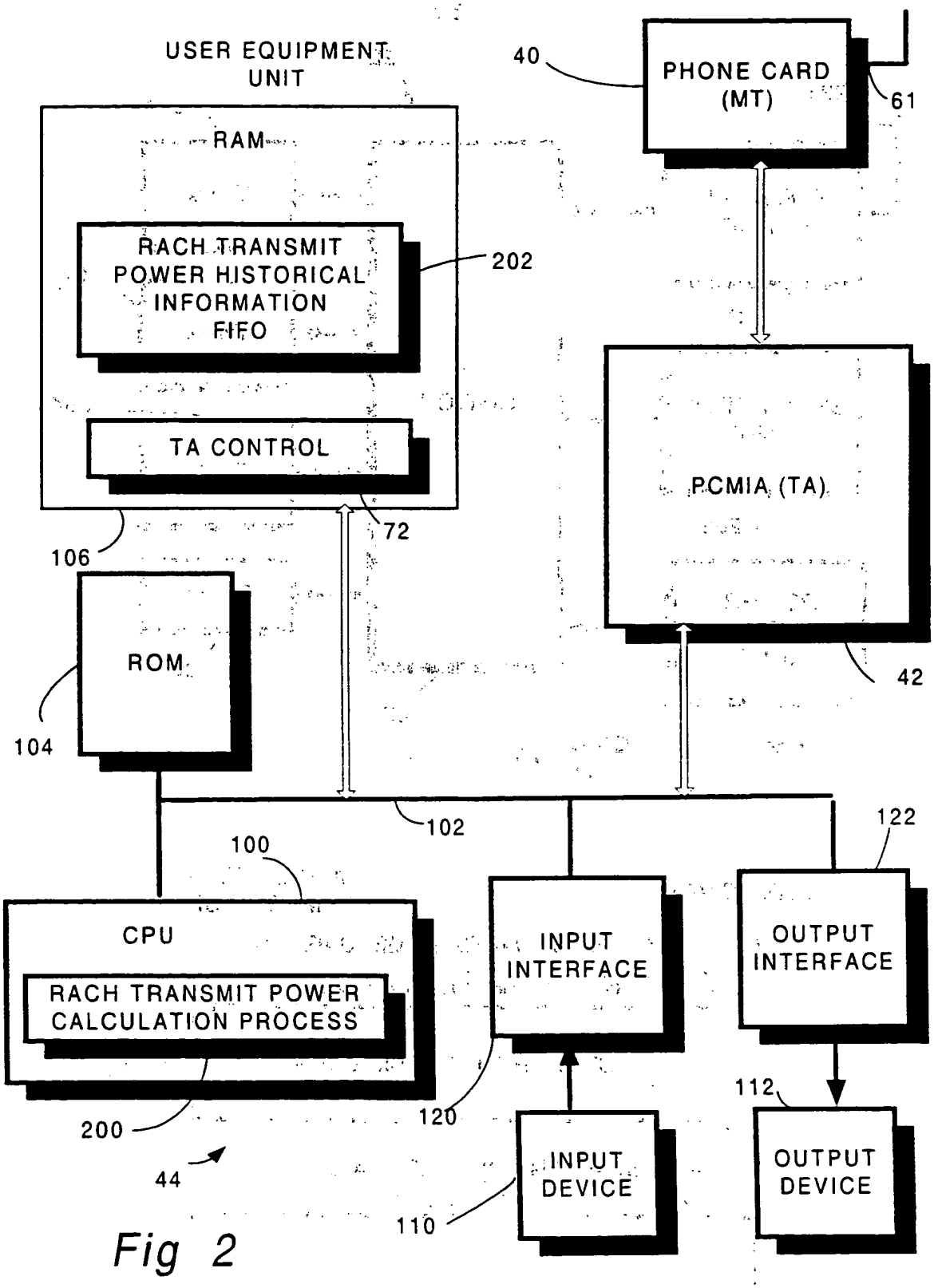

USER EQUIPMENT UNIT
RAM
RACH TRANSMIT POWER HISTORICAL INFORMATION FIFO
202
TA CONTROL
72
106
ROM
104
40
PHONE CARD (MT)
61
PCMIA (TA)
42
102
100
CPU
RACH TRANSMIT POWER CALCULATION PROCESS
200
44
INPUT INTERFACE
120
INPUT DEVICE
110
122
OUTPUT INTERFACE
112
OUTPUT DEVICE

Fig 2

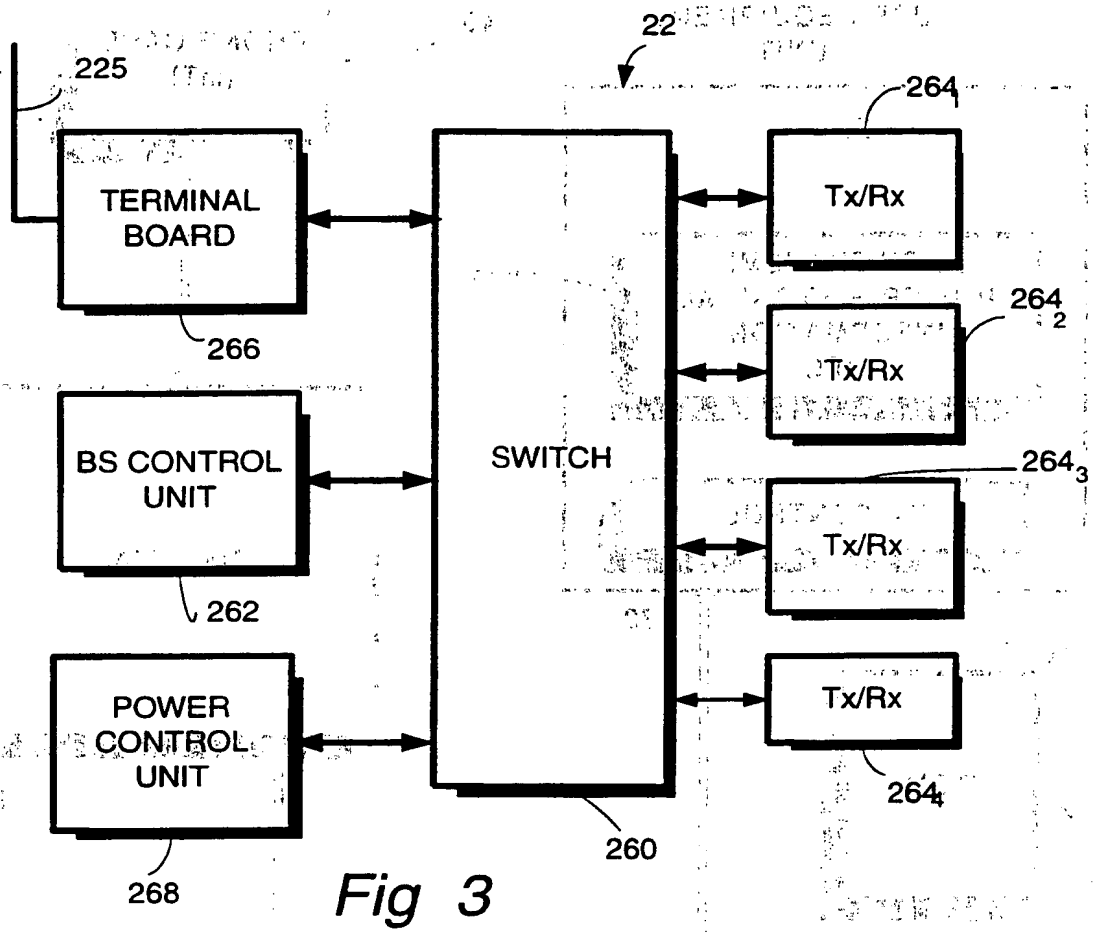

22
225
264 1
TERMINAL BOARD
Tx/Rx
266
264 2
Tx/Rx
BS CONTROL UNIT
SWITCH
264 3
Tx/Rx
262
POWER CONTROL UNIT
Tx/Rx
264 4
260
268

Fig 3

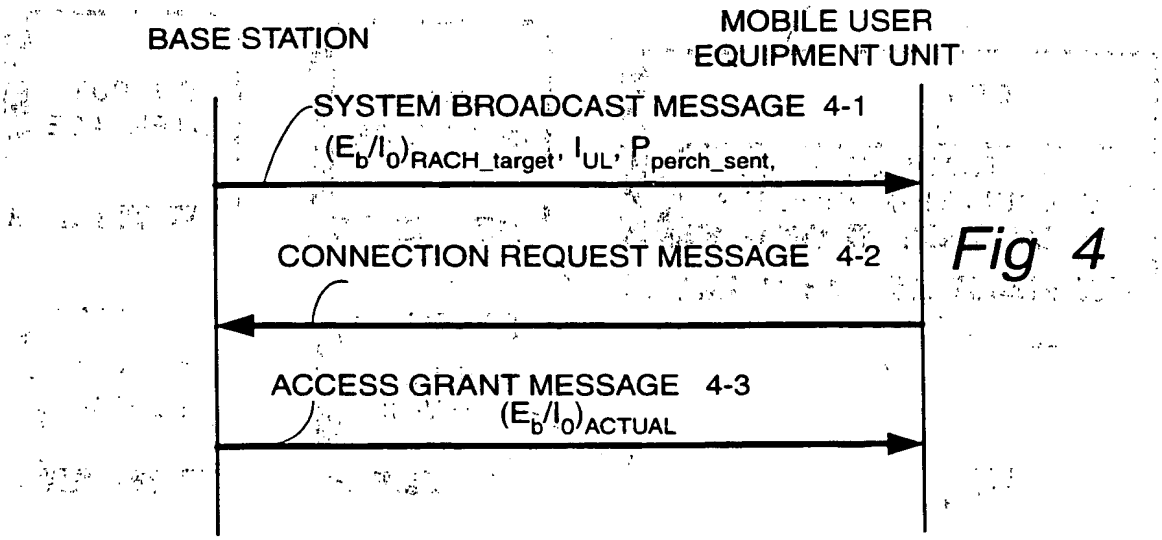
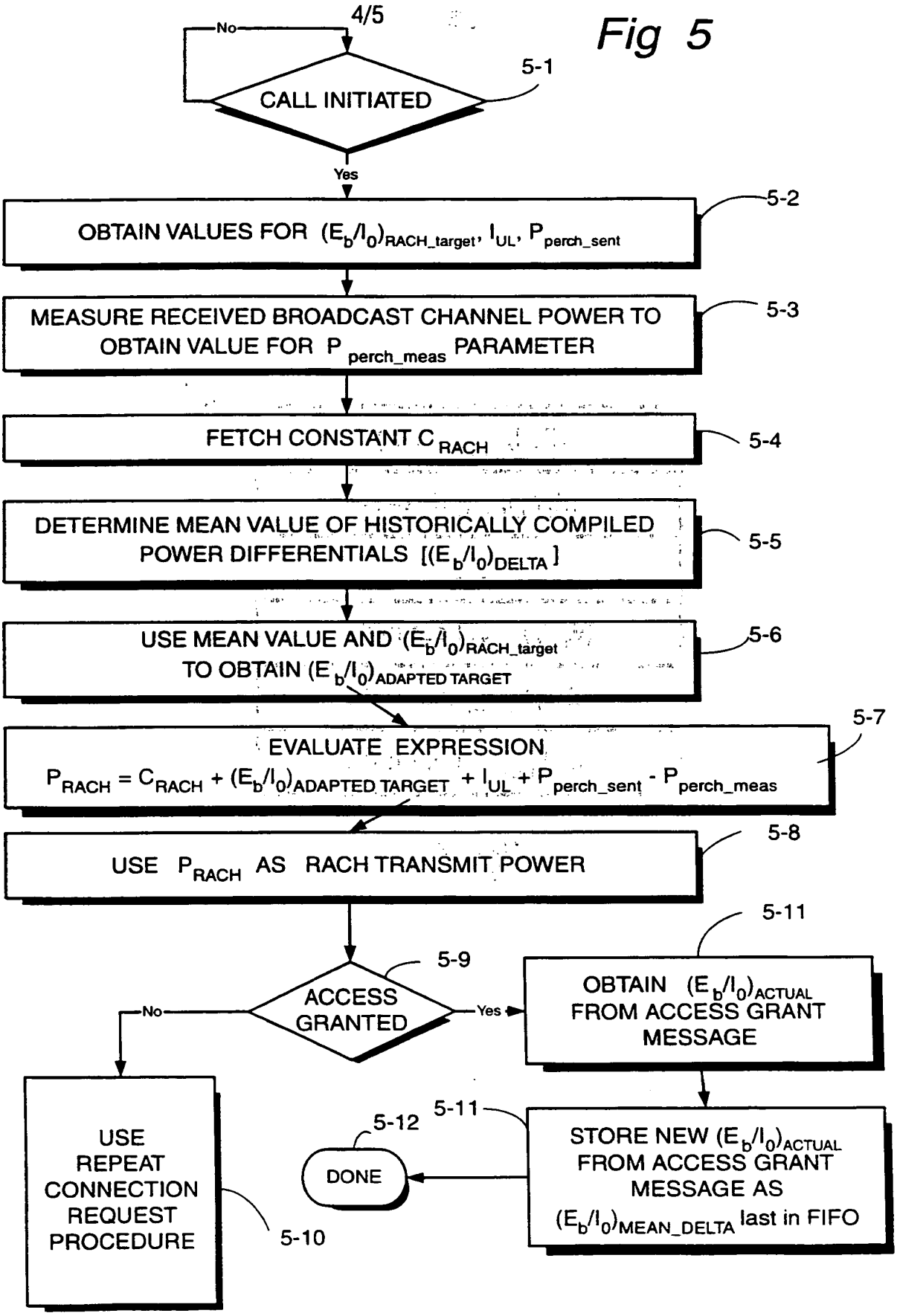

BASE STATION
MOBILE USER EQUIPMENT UNIT
SYSTEM BROADCAST MESSAGE 4-1
$(E_b/I_0)_{RACH_target}$, I_{UL}, P_{perch_sent},
CONNECTION REQUEST MESSAGE 4-2
ACCESS GRANT MESSAGE 4-3
$(E_b/I_0)_{ACTUAL}$

Fig 4

Fig 5


No
CALL INITIATED
5-1
Yes
OBTAIN VALUES FOR $(E_b/I_0)_{RACH_target}$, I_{UL}, P_{perch_sent}
5-2
MEASURE RECEIVED BROADCAST CHANNEL POWER TO OBTAIN VALUE FOR P_{perch_meas} PARAMETER
5-3
FETCH CONSTANT C_{RACH}
5-4
DETERMINE MEAN VALUE OF HISTORICALLY COMPILED POWER DIFFERENTIALS $[(E_b/I_0)_{DELTA}]$
5-5
USE MEAN VALUE AND $(E_b/I_0)_{RACH_target}$ TO OBTAIN $(E_b/I_0)_{ADAPTED\ TARGET}$
5-6
EVALUATE EXPRESSION
$P_{RACH} = C_{RACH} + (E_b/I_0)_{ADAPTED\ TARGET} + I_{UL} + P_{perch_sent} - P_{perch_meas}$
5-7
USE P_{RACH} AS RACH TRANSMIT POWER
5-8
ACCESS GRANTED
5-9
No
Yes
OBTAIN $(E_b/I_0)_{ACTUAL}$ FROM ACCESS GRANT MESSAGE
5-11
USE REPEAT CONNECTION REQUEST PROCEDURE
5-10
DONE
5-12
STORE NEW $(E_b/I_0)_{ACTUAL}$ FROM ACCESS GRANT MESSAGE AS $(E_b/I_0)_{MEAN_DELTA}$ last in FIFO
5-11

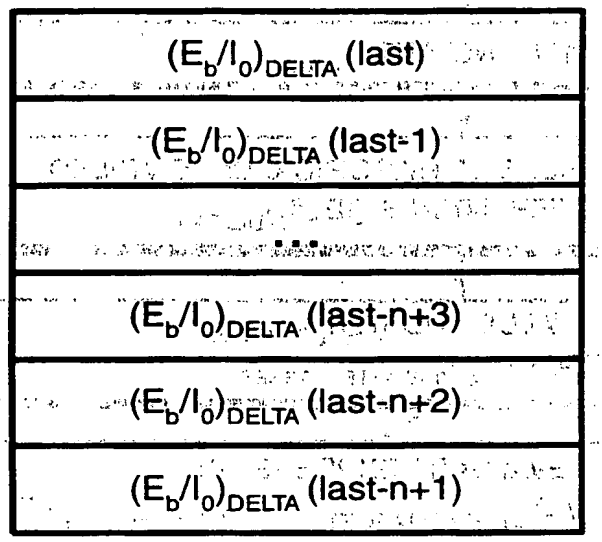

202
$(E_b/I_0)_{DELTA}$ (last)
$(E_b/I_0)_{DELTA}$ (last-1)
$(E_b/I_0)_{DELTA}$ (last-n+3)
$(E_b/I_0)_{DELTA}$ (last-n+2)
$(E_b/I_0)_{DELTA}$ (last-n+1)

Fig 6

INTERNATIONAL SEARCH REPORT

Inte ional Application No
PCT/SE 00/01958

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04B7/005 H04Q7/38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04B H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 564 075 A (GOURGUE FREDERIC) 8 October 1996 (1996-10-08)	1,2
A	column 1, line 64 -column 2, line 42 column 3, line 29 -column 4, line 13 column 4, line 30 -column 5, line 41	15
X	WO 97 07600 A (NOKIA MOBILE PHONES LTD ;SAARIO EIJA (FI)) 27 February 1997 (1997-02-27)	1
A	* abstract * page 3, line 22 -page 5, line 12 page 9, line 3 - line 32	15
X	US 5 806 003 A (JOLMA PETRI ET AL) 8 September 1998 (1998-09-08)	1
A	column 2, line 17 - line 38 column 3, line 66 -column 4, line 54; figure 4	15

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 March 2001	15/03/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Lõpez Márquez, T

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BNSDOCID: <WO 0128126A1 I >

INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/SE 00/01958

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 913 957 A (LUCENT TECHNOLOGIES INC) 6 May 1999 (1999-05-06)	1
A	column 1, line 47 -column 3, line 2 column 3, line 52 -column 4, line 36; figures 2,3	15
P,X	EP 0 989 691 A (LUCENT TECHNOLOGIES INC) 29 March 2000 (2000-03-29) * abstract * column 1, line 47 -column 2, line 20 column 3, line 27 - line 34 column 3, line 49 -column 4, line 32; figure 2	1,8-10, 15,24
A	WO 97 17769 A (MARTIN PAUL MAXWELL ;IONICA INT LTD (GB); GOODINGS RUPERT LESLIE A) 15 May 1997 (1997-05-15) *-abstract * page 1, line 13 -page 2, line 7 page 4, line 12 - line 19 page 9, line 22 -page 10, line 3 page 10, line 21 -page 11, line 16	1,15

1

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

BNSDOCID: <WO__ 0128126A1_I_>

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte. onal Application No
PCT/SE 00/01958

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		JP 2000500303 T	11-01-2000

BNSDOCID <WO 0128126A1 I >